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PRESSURE VESSEL GUIDELINES FOR COMPLIANCE OFFICERS

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PRESSURE VESSEL GUIDELINES FOR COMPLIANCE OFFICERS

A. INTRODUCTION

Pressure vessels present the ever present hazard of rupture or leakage failures. In order to reduce the likelihood of failure the Pressure Vessel Unit field engineers do inspections and issue “Permit to Operate” for the following types of pressure vessels:

1. Compressed Air Receivers, See Section 461

   Permits are issued for five years for stationary tanks and for three years for portable tanks. There are some exceptions for an Indefinite Permit and some small tanks not needing a permit at all. Plastic pipe is normally not allowed to be used with compressed air systems {See 462(m)}.

2. Liquid Petroleum Gas Tanks (Propane Tanks), See Section 470

   Permits are issued every three years for dispensing storage tanks over 125 gallons. Transportation tanks get five years permits.

3. Power Boilers (high pressure boilers over 15 psi steam pressure and usually indicated by an attached ASME Code Plate with an “S” surrounded by a clover leaf), See Section 770

   Permits to Operate are issued annually. Some large boilers with superior operation, maintenance, water-treatment etc., are given up to five years between internal inspections but must have external inspections every 6 months after the one year anniversary of the inspection.

A permit will have a State Number, from one to six numerals, a dash, and a two-digit numeral indicating the year of the first inspection. The number on the Permit to Operate should match the number that has been center punched into the tank or boiler; usually above or adjacent to the ASME Code Plate.

Permit information can be obtained by calling the Pressure Vessel Unit-Headquarters and giving the type of vessel and the State Number.

Pressure Vessel engineers are available to help with any accident investigation. Please call the Pressure Unit-Headquarters and one of the field engineers will be assigned.

Recent inspection programs for metallic pressure containment vessels and tanks have revealed cracking and damage in a considerable number of the vessels inspected.

Safety and hazard evaluations of pressure vessels need to consider the consequences of a leakage or a rupture failure of a vessel.

Two consequences result from a complete rupture:

* Blast effects due to sudden expansion of the pressurized fluid; and

* Fragmentation damage and injury, if vessel rupture occurs.

For a leakage failure, the hazard consequences can range from no effect to very serious effects:

* Suffocation or poisoning, depending on the nature of the contained fluid, if the leakage occurs into a closed space;

* Fire and explosion for a flammable fluid are included as a physical hazard; and

* Chemical and thermal burns from contact with process liquids.

Only pressure vessels and low pressure storage tanks widely used in process, pulp and paper, petroleum refining, and petrochemical industries and for water treatment systems of boilers and steam generation equipment are covered in this chapter. Excluded are vessels and tanks used in many other applications and also excludes other parts of a pressure containment system such as piping and valves.

The types and applications of pressure vessels included and excluded in this chapter are summarized in Table III:3-1. An illustration of a schematic pressure vessel is presented in Figure III:3-1.

NOTE: Though this review of pressure vessels excludes inspection or evaluation of safety release valves, the compliance officer should be aware that NO valves or T-fittings should be present between the vessel and the safety relief valve.

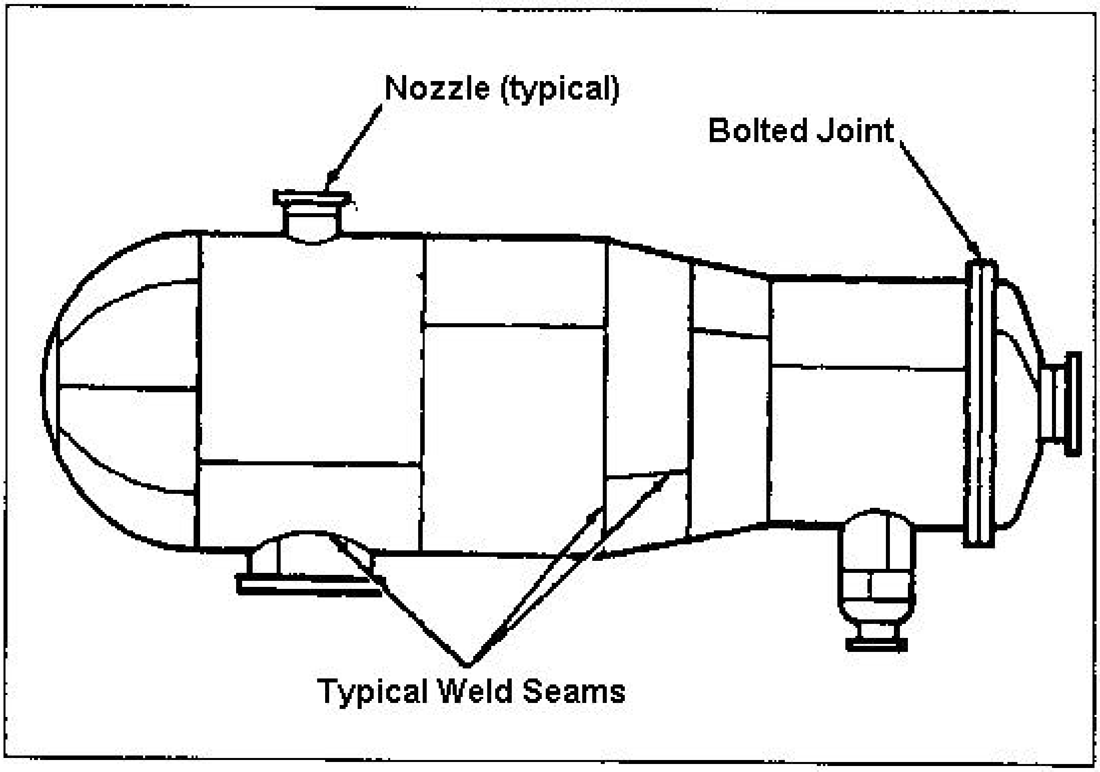

Figure III:3-1. Some Major Parts of a Pressure Vessel

Pressure Vessel Design Codes. Most of the pressure or storage vessels in service in the United States will have been designed and constructed in accordance with one of the following two design codes:

* Section VIII of the ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code; or

* The API Standard 620 or the American Petroleum Institute Code which provides rules for lower pressure vessels not covered by the ASME Code.

In addition, some vessels designed and constructed between 1934 to 1956 may have used the rules in the "API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases." This code was discontinued in 1956.

Vessels certification can only be performed by trained inspectors qualified for each code. Written tests and practical experience are required for certification. Usually, the compliance office is not equipped for this task, but is able to obtain the necessary contract services.

Table III:3-1. Vessel Types

Vessels included:	Vessel types specifically excluded:
Stationary and unfired	Vessels used as fired boiler
Used for pressure containment of gases and liquids	Vessels used in high-temperature processes (above 315°C, 600°F) or at very low and cryogenic temperatures
Constructed of carbon steel or low alloy steel	Vessels and containers used in transportable systems
Operated at temperatures between -75°C and 315°C (-100°F and 600°F)	Storage tanks that operate at nominally atmospheric pressure
	Piping and Pipelines
	Safety and pressure-relief valves
	Special-purpose vessels, such as those for human occupancy.

B. RECENT CRACKING EXPERIENCE IN PRESSURE VESSELS

DEAERATOR SERVICE

Deaeration refers to the removal of noncondensible gases, primarily oxygen, from the water used in a steam generation system.

Deaerators are widely used in many industrial applications including power generation, pulp and paper, chemical, and petroleum refining and in many public facilities such as hospitals and schools where steam generation is required. In actual practice, the deaerator vessel can be separate from the storage vessel or combined with a storage vessel into one unit.

Typical operational conditions for deaerator vessels range up to about 300 psi and up to about 150°C (300°F). Nearly all of the vessels are designed to ASME Code resulting in vessel wall thicknesses up to but generally less than 25 mm (1 in). The vessel material is almost universally one of the carbon steel grades.

Analysis of incident survey data and other investigations has determined the following features about the deaerator vessel cracking.

- Water hammer is the only design or operational factor that correlates with cracking.
- Cracking is generally limited to weld regions of vessels that had not been postweld heat treated.
- Corrosion fatigue appears to be the predominant mechanism of crack formation and growth.

The failures and the survey results have prompted TAPPI (Technical Association of Pulp and Paper Industry), the National Board of Boiler and Pressure Vessel Inspectors, and NACE (National Association of Corrosion Engineers) to prepare inspection, operation and repair recommendations.

For inspection, all recommendations suggest:

- Special attention to the internal surface of all welds and heat-affected zones (HAZ); and
- Use of the wet fluorescent magnetic particle (WFMT) method for inspection.

The TAPPI and the NACE recommendations also contain additional items, such as:

- Inspection by personnel certified to American Society for Nondestructive Testing's SNT-TC-1A minimum Level I and interpretation of the results by minimum Level II; and

- Reinspection within one year for repaired vessels, 1-2 years for vessels with discontinuities but unrepaired, and 3-5 years for vessels found free of discontinuities.

AMINE SERVICE

The amine process is used to remove hydrogen sulfide (H_2S) from petroleum gases such as propane and butane. It is also used for carbon dioxide (CO_2) removal in some processes. Amine is a generic term and includes monoethanolamine (MEA), diethanolamine (DEA) and others in the amine group. These units are used in petroleum refinery, gas treatment and chemical plants.

The operating temperatures of the amine process are generally in the 38°C to 93°C (100°F to 200°F) range and therefore the plant equipment is usually constructed from one of the carbon steel grades. The wall thickness of the pressure vessels in amine plants is typically about 25 mm (1 in).

Although the possibility of cracking of carbon steels in an amine environment has been known for some years, real concern about safety implications was highlighted by a 1984 failure of the amine process pressure vessel. Overall, the survey found about 40% cracking incidence in a total of 294 plants. Cracking had occurred in the absorber/contactor, the regenerator and the heat exchanger vessels, and in the piping and other auxiliary equipment. Several of the significant findings of the survey were:

- All cracks were in or near welds.

- Cracking occurred predominantly in stressed or unrelieved (not PWHT) welds.

- Cracking occurred in all amine vessel processes but was most prevalent in MEA units.

- WFMT and UT (ultrasonic test) were the predominant detection methods for cracks; internal examination by WFMT is the preferred method.

Information from laboratory studies indicate that pure amine does not cause cracking of carbon steels but amine with carbon dioxide in the gas phase causes severe cracking. The presence or absence of chlorides, cyanides, or hydrogen sulfide may also be factors but their full role in the cracking mechanism are not completely known at present.

WET HYDROGEN SULFIDE

Wet Hydrogen Sulfide refers to any fluid containing water and hydrogen sulfide (H_2S). Hydrogen is generated when steel is exposed to this mixture and the hydrogen can enter into the steel. Dissolved hydrogen can cause cracking, blistering, and embrittlement.

The harmful effects of hydrogen generating environments on steel have been known and recognized for a long time in the petroleum and petrochemical industries. In particular, sensitivity to damage by hydrogen increases with the hardness and strength of the steel and damage and cracking are more apt to occur in high strength steels.

- Significant cracks can start from very small hard zones associated with welds; these hard zones are not detected by conventional hardness tests.
- Initially small cracks can grow by a stepwise form of hydrogen blistering to form through thickness cracks.
- NACE/API limits on weld hardness may not be completely effective in preventing cracking.
- Thermal stress relief (postweld heat treatment, PWHT) appears to reduce the sensitivity to and the severity of cracking.

Wet hydrogen sulfide has also been found to cause service cracking in liquified petroleum gas (LPG) storage vessels. The service cracking in the LPG vessels occurs predominantly in the weld heat affected zone (HAZ). The vessels are usually spherical with wall thickness in the 20 mm to 75 mm (0.8 in to 3 in) range.

Recommendations for new and existing wet hydrogen-sulfide vessels to minimize the risk of a major failure include:

- Use lower-strength steels for new vessels;
- Schedule an early inspection for vessels more than five years in service;
- Improve monitoring to minimize breakthrough of hydrogen sulfide; and
- Replace unsafe vessels or downgrade to less-severe, usually lower-pressure, service.

AMMONIA SERVICE

Commercial refrigeration systems, certain chemical processes, and formulators of agricultural chemicals will be sites of ammonia service tanks.

Careful inspections of vessels used for storage of ammonia (in either vapor or liquid form) in recent years have resulted in evidence of serious stress corrosion cracking problems.

The vessels for this service are usually constructed as spheres from one of the carbon steel grades, and they operate in the ambient temperature range.

The water and oxygen content in the ammonia has a strong influence on the propensity of carbon steels to crack in this environment.

Cracks have a tendency to be found to be in or near the welds in as-welded vessels. Cracks occur both transverse and parallel to the weld direction. Thermal stress relieving seems to be a mitigating procedure for new vessels, but its efficacy for older vessels after a period of operation is dubious partly because small, undetected cracks may be present.

PULP DIGESTER SERVICE

The kraft pulping process is used in the pulp and paper industry to digest the pulp in the papermaking process. The operation is done in a relatively weak (a few percent) water solution of sodium hydroxide and sodium sulfide typically in the 110°C to 140°C (230°F to 285°F) temperature range. Since the early 1950s, a continuous version of this process has been widely used. Nearly all of the vessels are ASME Code vessels made using one of the carbon steel grades with typical design conditions of 175°C to 180°C (350°F to 360°F) and 150 psig.

These vessels had a very good service record with only isolated reports of cracking problems until the occurrence of a sudden rupture failure in 1980. The inspection survey has revealed that about 65% of the properly inspected vessels had some cracking. Some of the cracks were fabrication flaws revealed by the use of more sensitive inspection techniques but most of the cracking was service-induced. The inspection survey and analysis indicates the following features about the cracking.

- All cracking was associated with welds.
- Wet fluorescent magnetic particle (WFMT) testing with proper surface preparation was the most effective method of detecting the cracking.
- Fully stress-relieved vessels were less susceptible.
- No clear correlation of cracking and noncracking could be found with vessel age and manufacture or with process variables and practices.
- Analysis and research indicate that the cracking is due to a caustic stress corrosion cracking mechanism although its occurrence at the relatively low caustic concentrations of the digester process was unexpected.

Currently, preventive measures such as weld cladding, spray coatings, and anodic protection are being studied, and considerable information has been obtained. In the meantime, the recommended guideline is to perform an annual examination.

SUMMARY OF SERVICE CRACKING EXPERIENCE

The preceding discussion shows a strong influence of chemical environment on cracking incidence. This is a factor that is not explicitly treated in most design codes. Service experience is the best and often the only guide to in-service safety assessment.

For vessels and tanks within the scope of this document, the service experience indicates that the emphasis of the inspection and safety assessment should be on:

- Vessels in deaerator, amine, wet H2S, ammonia and pulp digesting service;

- Welds and adjacent regions;

- Vessels that have not been thermally stress relieved (no PWHT of fabrication welds); and

- Repaired vessels, especially those without PWHT after repair.

The evaluation of the severity of the detected cracks can be done by fracture mechanics methods. This requires specific information about stresses, material properties, and flaw indications. Generalized assessment guidelines are not easy to formulate. However, fortunately, many vessels in the susceptible applications listed above operate at relatively low stresses, and therefore, cracks have a relatively smaller effect on structural integrity and continued safe operation.

C. NONDESTRUCTIVE EXAMINATION METHODS

Of the various conventional and advanced nondestructive examination (NDE) methods, five are widely used for the examination of pressure vessels and tanks by certified pressure vessel inspectors. The names and acronyms of these common five methods are:

VT Visual Examination,

PT Liquid Penetrant Test,

MT Magnetic Particle Test,

RT Gamma and X-ray Radiography, and

UT Ultrasonic Test.

VT, PT and MT can detect only those discontinuities and defects that are open to the surface or are very near the surface. In contrast, RT and UT can detect conditions that are located within the part. For these reasons, the first three are often referred to as "surface" examination methods and the last two as "volumetric" methods.

VISUAL EXAMINATION (VT)

A visual examination is easy to conduct and can cover a large area in a short time.

It is very useful for assessing the general condition of the equipment and for detecting some specific problems such as severe instances of corrosion, erosion, and hydrogen blistering. The obvious requirements for a meaningful visual examination are a clean surface and good illumination.

LIQUID PENETRANT TEST (PT)

This method depends on allowing a specially formulated liquid (penetrant) to seep into an open discontinuity and then detecting the entrapped liquid by a developing agent. When the penetrant is removed from the surface, some of it remains entrapped in the discontinuities. Application of a developer draws out the entrapped penetrant and magnifies the discontinuity. Chemicals which fluoresce under black (ultraviolet) light can be added to the penetrant to aid the detectability and visibility of the developed indications. The essential feature of PT is that the discontinuity must be "open," which means a clean, undisturbed surface.

The PT method is independent of the type and composition of the metal alloy so it can be used for the examination of austenitic stainless steels and nonferrous alloys where the magnetic particle test is not applicable.

MAGNETIC PARTICLE TEST (MT)

This method depends on the fact that discontinuities in or near the surface perturb magnetic flux lines induced into a ferromagnetic material. For a component such as a pressure vessel where access is generally limited to one surface at a time, the "prod" technique is widely used. The magnetic field is produced in the region around and between the prods (contact probes) by an electric current (either AC or DC) flowing between the prods. The ferromagnetic material requirement basically limits the applicability of MT to carbon and low-alloy steels.

The perturbations of the magnetic lines are revealed by applying fine particles of a ferromagnetic material to the surface. The particles can be either a dry powder or a wet suspension in a liquid. The particles can also be treated to fluoresce under black light. These options lead to variations such as the "wet fluorescent magnetic particle test" (WFMT).

MT has some capability for detecting subsurface defects. However, there is no easy way to determine the limiting depth of sensitivity since it is highly dependent on magnetizing current, material, and geometry and size of the defect. A very crude approximation would be a depth no more than 1.5 mm to 3 mm (1/16 in to 1/8 in).

A very important precaution in performing MT is that corners and surface irregularities also perturb the magnetic field. Therefore, examining for defects in corners and near or in welds must be performed with extra care. Another precaution is that MT is most sensitive to discontinuities which are oriented transverse to the magnetic flux lines and this characteristic needs to be taken into account in determining the procedure for inducing the magnetic field.

RADIOGRAPHY (RT)

The basic principle of radiographic examination of metallic objects is the same as in any other form of radiography such as medical radiography. Holes, voids, and discontinuities decrease the attenuation of the X-ray and produce greater exposure on the film (darker areas on the negative film).

Because RT depends on density differences, cracks with tightly closed surfaces are much more difficult to detect than open voids. Also, defects located in an area of a abrupt dimensional change are difficult to detect due to the superimposed density difference. RT is effective in showing defect dimensions on a plane normal to the beam direction but determination of the depth dimension and location requires specialized techniques.

Since ionizing radiation is involved, field application of RT requires careful implementation to prevent health hazards.

DETECTION PROBABILITIES AND FLAW SIZING

The implementation of NDE (nondestructive examination) results for structural integrity and safety assessment involves a detailed consideration of two separate but interrelated factors.

- Detecting the discontinuity.
- Identifying the nature of the discontinuity and determining its size.

Much of the available information on detection and sizing capabilities has been developed for aircraft and nuclear power applications. This kind of information is very specific to the nature of the flaw, the material, and the details of the test technique, and direct transference to other situations is not always warranted.

The overall reliability of NDE is obviously an important factor in a safety and hazard assessment. Failing to detect or undersizing existing discontinuities reduces the safety margin while oversizing errors can result in unnecessary and expensive outages. High reliability results from a combination of factors.

- Validated procedures, equipment and test personnel.
- Utilization of diverse methods and techniques.
- Application of redundancy by repetitive and independent tests.

Finally, it is useful to note that safety assessment depends on evaluating the "largest flaw that may be missed, not the smallest one that can be found."

ULTRASONIC TESTING (UT)

The fundamental principles of ultrasonic testing of metallic materials are similar to radar and related methods of using electromagnetic and acoustic waves for detection of foreign objects. The distinctive aspect of UT for the inspection of metallic parts is that the waves are mechanical, so the test equipment requires three basic components.

- Electronic system for generating electrical signal.
- Transducer system to convert the electrical signal into mechanical vibrations and vice versa and to inject the vibrations into and extract them from the material.
- Electronic system for amplifying, processing and displaying the return signal.

Very short signal pulses are induced into the material and waves reflected back from discontinuities are detected during the "receive" mode. The transmitting and detection can be done with one transducer or with two separate transducers (the tandem technique).

Unlike radiography, UT in its basic form does not produce a permanent record of the examination. However, more recent versions of UT equipment include automated operation and electronic recording of the signals.

Ultrasonic techniques can also be used for the detection and measurement of general material loss such as by corrosion and erosion. Since wave velocity is constant for a specific material, the transit time between the initial pulse and the back reflection is a measure of the travel distance and the thickness.

T-MIKE OPERATION

Principle of Operation

The principle of operation of an ultrasonic thickness gauge is that the instrument measures the time of flight of an ultrasonic pulse through the test piece and multiplies this time by the velocity of sound in the material. Thickness measuring error is minimized by ensuring that the sound velocity to which the instrument is calibrated is the sound velocity of the material being tested. Actual sound velocity in materials often vary significantly from the values found in published tables. In all cases, best results are obtained if the instrument is calibrated on a velocity reference block made from the same material as the test piece; this block should be flat and smooth and as thick as the maximum thickness of the test piece.

The operator should also be aware that sound velocity may not be constant in the material being tested: heat treating, for example can cause significant changes in sound velocity. This must be considered when evaluating the accuracy of the thickness provided by this instrument. Instruments should always be calibrated before testing and the calibration should be checked after testing, to minimize errors.

Testing Limitations

In ultrasonic testing, information is obtained only from within the limits of the sound beam. Operators must exercise great caution in making inferences about the test material outside the limits of the sound beam. For example, when testing large materials, it may be impossible or impractical to inspect the entire test piece. When a less-than-complete inspection is to be performed, the operator must be shown the specific areas to inspect. Materials subject to corrosion or erosion, in which conditions can vary significantly in any given area, should be evaluated only by fully trained and experienced operators.

Sound beams reflect from the first interior surface encountered. Because of part geometry and overlapped flaws or overlapped surface, thickness gauges may measure the distance to an internal flaw rather than to the back wall of the material. Operators must take steps to ensure that the entire thickness of the test material is being examined.

Variations in temperature change the sound velocity of materials and transducer delay lines and therefore, zero calibration. All calibrations should be performed at the same temperature in order to minimize errors due to temperature variations.

Probe Zero

The probe zero procedure must be performed as described before each use. The zero reference block should be clean and in good condition, without noticeable wear. Failure to properly perform the probe zero procedure will result in inaccurate thickness readings.

Each transducer (probe) and the electronics varies in the amount of time to transmit the signal to be measured. This time must be subtracted from the total transmission time. The time correction is accomplished automatically by performing a "PROBE" recognition operation.

Transducer

The transducer used in testing must be in good condition without noticeable wear of the front surface. Badly worn transducers will have a reduced effective measuring range. The specified range of the transducer must include the complete range of thickness to be tested. The temperature of the material to be tested must be within the transducer's temperature range.

Use of Couplants

Operators must be familiar with the use of ultrasonic couplants. Testing skills must be developed so that couplant is used and applied in a consistent manner to minimize variations in couplant layer thickness and errors in test results. Calibration and actual testing should be performed under similar coupling conditions, using a minimum of couplant and applying consistent pressure on the transducer.

Doubling

Ultrasonic thickness gauges will, under certain conditions, display readings which are twice (or in some cases, three times) the actual material thickness being measured. This effect, commonly known as "doubling", can occur below the minimum specified range of the transducer. If the transducer being used is worn, doubling is possible at a thickness greater than the minimum specified range.

When using a <u>new</u> transducer, any reading which is <u>less than twice</u> the minimum specified range of the transducer may be a "doubled" reading (minimum specified range 0.040 X 2 = 0.080), and the thickness of the material being tested should be verified by the use of other methods. If the transducer shows any sign of <u>wear</u>, doubling may occur at a thickness <u>greater than twice</u> the minimum specific range (0.080). Calibrating on reference blocks that represent the complete range of all possible thickness that may be encountered in testing should take care of this problem.

Configuration and Calibration

The T-Mike Programmable is preset to display in inches; the backlight enabled; and the sound velocity fixed. This is done at the Oakland and Anaheim offices using an IBM compatible computer running special software. The T-Mike Programmable should be returned to one these offices for calibration at least once a year or whenever there is reason to question the accuracy of the thickness readings.

Programming from an IBM Compatible PC

1. Using the special cable, connect the T-Mike Programmable to a serial 9 pin male connector or serial 25 pin female connector on the back of the computer. Note if this is port 1 or port 2.

2. Run **SETTMIKE.** Choose Inches by entering "**I**" then press **ENTER**.

3. Enter the sound velocity in inches per second, (0.23300) and press **ENTER**. Use the correct number of zeros!

4. The program asks if you want backlight enabled. Enter "**Y**" then press **ENTER**.

5. The program asks to which communication port the T-Mike Programmable is connected. Press either 1 or 2 followed by **ENTER**.

6. Turn on power to the T-Mike Programmable by pressing and releasing the **ON/OFF** button on the T-Mike Programmable.

7. The T-Mike Programmable displays **CAL**, followed by the new velocity and goes into measurement mode.

8. Test T-Mike Programmable on a material sample to verify that is reads the correct thickness.

On/Off Function

Press this key to turn the T-Mike Programmable on. The unit will briefly display the sound velocity in inches per second (0.2330 in/µs), then display a reading of zero. The T-Mile Programmable is now ready for measurement or **Probe Zero**. In order to compensate for any change in the ultrasonic transducer, a **Probe Zero** function should be performed at this point.

Probe Zero Function

The **Probe Zero** function compensates the T-Mike Programmable for the fixed delay of the ultrasonic transducer. This function should be performed at the start of each day to compensate for transducer wear or whenever the transducer is changed.

1. Apply a drop of couplant to the end of the transducer.

2. Press the ON/OFF button on the keyboard to turn on the T-Mike Programmable.

3. Place the transducer in steady contact with the probe disk located on the top of the T-Mike Programmable. <u>Do not use another 0.250 test piece since the velocity of the probe disk is carefully controlled and errors will result</u>. The T-Mike Programmable recognizes that the probe is in contact with the probe disk, and automatically performs the Probe Zero Function.

4. Upon completion of the function **Prb 0** will appear on the display indicating that the appropriate transducer delay factor has been entered in memory.

Thickness Measurement

1. Remove dirt, loose material and couplant residue from the surface of material at points where measurements are desired.

2. Perform the PROBE ZERO function.

3. Place a drop of couplant on the material surface at the measurement point.

4. Place the transducer in steady contact with the surface of the material at the measurement point. **Do not scrub the face of the transducer against the material being measured**.

5. When a detectable echo is received from the back surface of the material, the echo indicator in the upper right of the display will indicate the detection of an echo by changing in appearance to represent contact between the pictured transducer and the sample surface.

6. The T-Mike Programmable will display the thickness of the material in inches.

Note: If the detected echo is of marginal magnitude, a question mark (?) will appear to the left of the echo indicator. This will alert the operator that the measurement may be subject to error, and steps should be taken to improve the transducer coupling or position.

If no echo is detected for a period of 4.5 minutes, T-Mike Programmable will automatically switch to its low power or dormant state as indicated by the display becoming blank. In this state probe and velocity calibration factors are retained in memory. Operation may be resumed immediately by pressing the power key.

The T-Mike Programmable automatically monitors the charge state of the battery to insure that sufficient charge is available to operate the unit properly. When the T-Mike Programmable detects minimum allowable battery level the numbers on the display will blink on and off. This alerts the operator that the batteries should be replaced or recharged before further operation. When the battery level falls below the minimum allowable level the T-Mike Programmable will turn off and not allow further operation until batteries are replaced or recharged.

Replacing or Recharging Batteries

The T-Mike Programmable comes standard with 4AA alkaline batteries. The user may elect to use rechargeable NiCad AA batteries which can be inserted as a direct replacement of the alkaline cells. To change the batteries, loosen the screw on the bottom end cap and remove the spent batteries. Replace the batteries with fresh Alkaline AA cells or recharged NiCad AA cells.

Care must be used to replace the batteries in the correct polarity as indicated on the battery holder.

Note: After changing batteries, be sure to perform the PROBE ZERO procedure and recalibrate the T-Mike Programmable for the material to be measured.

Transducer and Cable

Check the cable for cuts or punctures. Check if the connectors are on tightly. If the T-Mike E always indicates an echo when the transducer is connected, look for a piece of metal jammed in the cross talk barrier of the transducer. The cross talk barrier is the line separating the two halves of the transducer.

Optional Nicad Battery

NiCad batteries have a “memory” that destroys their capacity if the battery is not cycled. Do not constantly charge the T-Mike Programmable. Maximum battery life is obtained by discharging the battery through normal use before recharging.

If you operate the T-Mike Programmable beyond the flashing display warning to the point below the minimum acceptable battery voltage, the T-Mike Programmable will automatically shut off and will not restart until the charger is connected or the batteries are replaced. Data will be retained for approximately four hours, do replace the battery pack as soon as possible.

Keypad and Display

If the keypad or the LCD malfunction, the T-Mike Programmable should be returned to either the Oakland or Anaheim office for replacement or repair.

While the LCD is made of glass, the front surface of the display contains a plastic polarizer. **Do not** clean the surface of the display with any solvents or abrasives.

D. INFORMATION FOR SAFETY ASSESSMENT

Though the compliance officer is not usually qualified as a pressure vessel inspector, as a summary and a reminder, Appendix III:3-1 outlines the information, data, and recordkeeping that are necessary, useful, or indicative of safe management of operating vessels and tanks.

These records, besides the construction and maintenance logs usually are kept by the plant engineer, maintenance supervisor, or facility manager, will be indicative of the surveillance activities around safe operation of pressure vessels.

For further assistance contact the Pressure Vessel Unit-Headquarters.

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APPENDIX III:3-1. RECORDKEEPING DATA FOR STEEL VESSELS AND LOW PRESSURE STORAGE TANKS

INTRODUCTION AND SCOPE

This outline summarizes information and data that will be helpful in assessing the safety of steel pressure vessels and low pressure storage tanks that operate at temperatures between -75°C and 315°C (-100°F and 600°F).

VESSEL IDENTIFICATION AND DOCUMENTATION

Information that identifies the specific vessel being assessed and provides general information about it include the following items:

* Current owner of the vessel

* Vessel location
  Original location and current location if it has been moved

* Vessel identification
  Manufacturer's serial number
  National Board number if registered with NB

* Manufacturer identification
  Name and address of manufacturer
  Authorization or identification number of the manufacturer

* Date of manufacture of the vessel

* Data report for the vessel
  ASME U-1 or U-2, API 620 form or other applicable report

* Date vessel was placed in service

* Interruption dates if not in continuous service.

DESIGN AND CONSTRUCTION INFORMATION

Information that will identify the code or standard used for the design and construction of the vessel or tank and the specific design values, materials, fabrication methods, and inspection methods used include the following items:

* Design code
  ASME Code Section and Division, API Standard or other design code used

* Type of construction
  Shop or field fabricated or other fabrication method

* VIII, division 1 or 2 vessels
  Maximum allowable pressure and temperature
  Minimum design temperature

* API 620 vessels
  Design pressure at top and maximum fill

* Additional requirements included such as
  Appendix Q (Low-Pressure Storage Tanks For Liquified Hydrocarbon Gases) and
  Appendix R (Low-Pressure Storage Tanks for Refrigerated Products)

* Other design code vessels
  Maximum design and allowable pressures
  Maximum and minimum operating temperatures

* Vessel materials
  ASME, ASTM, or other specification names and numbers for the major parts

* Design corrosion allowance

* Thermal stress relief (PWHT, postweld heat treatment)
  Design code requirements
  Type, extent, and conditions of PWHT performed

* Nondestructive examination (NDE) of welds
  Type and extent of examination performed
  Time when NDE was performed (before or after PWHT or hydrotest)

SERVICE HISTORY

Information on the conditions of operating history of the vessel or tank
that will be helpful in safety assessment include the following items:

* Fluids handled
  Type and composition, temperature and pressures

* Type of service
  Continuous, intermittent or irregular

* Significant changes in service conditions
  Changes in pressures, temperatures, and fluid compositions and the dates of the changes

* Vessel history
  Alterations, reratings, and repairs performed
  Date(s) of changes or repairs

IN-SERVICE INSPECTION

Information about inspections performed on the vessel or tank and the results obtained that will assist in the safety assessment include the following items:

* Inspection(s) performed
  Type, extent, and dates

* Examination methods
  Preparation of surfaces and welds
  Techniques used (visual, magnetic particle, penetrant test, radiography, ltrasonic)

* Qualifications of personnel
  ASNT (American Society for Nondestructive Testing) levels or equivalent of examining and supervisory personnel

* Inspection results and report
  Report form used (NBIC NB-7, API 510 or other)
  Summary of type and extent of damage or cracking
  Disposition (no action, delayed action or repaired)

SPECIFIC APPLICATIONS

Survey results indicate that a relatively high proportion of vessels in operations in several specific applications have experienced inservice related damage and cracking. Information on the following items can assist in assessing the safety of vessels in these applications:

* Service application
  Deaerator, amine, wet hydrogen sulfide, ammonia, or pulp digesting

* Industry bulletins and guidelines for this application
  Owner/operator awareness of information

* Type, extent, and results of examinations
    Procedures, guidelines and recommendations used
    Amount of damage and cracking
    Next examination schedule

* Participation in industry survey for this application

* Problem mitigation
    Written plans and actions

EVALUATION OF INFORMATION

The information acquired for the above items is not adaptable to any kind of numerical ranking for quantitative safety assessment purposes. However, the information can reveal the owner or user's apparent attention to good practice, careful operation, regular maintenance, and adherence to the recommendations and guidelines developed for susceptible applications. If the assessment indicated cracking and other serious damage problems, it is important that the inspector obtain qualified technical advice and opinion.